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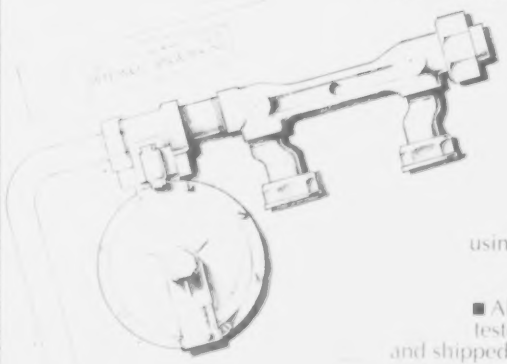

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## FEATURES

**ON THE COVER**
U.S. gas utilities will install thousands of miles of plastic mains and services in 1991 and 1992 to serve new customers as well as improve the service to existing users. (Photo courtesy Washington Gas Light)

**NEXT MONTH** P&GJ's U.S./Canadian Report will provide details on new and proposed pipeline projects, a study on U.S. pipeline flow patterns and updates on major energy pipeline construction efforts.


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Special Report

# Gas Utility Spending Stays At High Level

**26th Annual**
**PIPELINE & GAS JOURNAL**
**Distribution Piping Report**

Despite being buffeted by warmer-than-usual weather and a decline in residential construction, U.S. gas utilities spent more than $4.15 billion in 1991 to maintain the existing distribution system and extend gas service to new customers. Next year should be a busy year for gas companies and contractors across the U.S., with expected expenditures of $4.4 billion and installation of more than 27,000 miles of steel and plastic mains and services.

Gas utility spending should stay above the $4-billion market for several years, according to utility executives surveyed for the 26th Annual PIPELINE & GAS JOURNAL Distribution Piping Report, as new customers are added and aging, existing distribution systems are maintained, upgraded and replaced.

The 3Rs—Repair, Rehabilitate, Replacement—activities accounted for 53.6% of the total 1991 gas utility construction maintenance expenditures, as gas utilities pay close attention to protecting their investment in distribution networks. However, projections for 1992 show the 3Rs maintaining only a slight edge over new construction, with 50.2% of the total.

Utilities installed a total of 25,654 miles of gas distribution piping in 1991. Expected mileage for 1992 is 26,144 miles of pipeline.

U.S. gas utilities spent a total of $1,928,472,000 on installation of new pipeline to serve a growing customer base. Natural gas is attractive for many reasons, and utilities are expanding their systems to serve communities that did not have gas service. New construction activities accounted for 46.4% of the total $4,157,778,000 spent by U.S. gas utilities in 1991.

Expenditures for 1992 new construction are expected to reach $2.193 billion, or 49.8% of total anticipated expenditures of $4.4 billion next year.

New pipeline mileage installed during 1991 to serve new customers totaled 17,537 miles, including 10,085 miles of mains and 7,452 miles of service lines.

In 1992, companies said they expect to install a total of 19,071 miles of pipeline to serve new customers, including 10,707 miles of new mains and 8,364 miles of new service lines.

Although many companies rely on distribution contractors for all or part of their new construction work, survey results indicate that U.S. gas utilities spent $860.070 million on new construction equipment in 1991, going to an expected $900.675 million in 1992.

As has been the case in recent years, 3Rs activities continued to dominate gas utility budgets in 1991. An estimated $2.229 billion was spent on maintaining, upgrading and otherwise improving the U.S. gas distribution network in 1991, with expected expenditures for 1992 exceeding $2.206 billion.

The 3Rs accounted for 53.6% of total expenditures in 1991, but will come into balance with new construction costs in 1992, with an anticipated 50.2% of the budget.

U.S. gas utilities installed 8,117 miles of replacement pipeline in 1991, including 3,575 miles of replacement mains and 4,542 miles of replacement services. Replacement mileage in 1992 will total 8,073 miles, including 3,688 miles of replacement mains and 4,385 miles of replacement service lines.

Most companies said the relatively warm winter of 1990-91 affected their construction and repair budgets, but others said their expenditures are based on system needs rather than outside factors.

There has been a continuous decline in new business activity in 1991, reflective of the current eco-

**New and Replacement Mains and Services, 1989-1992**

| | 1992 | 19991 | 1990 | 1989 |
|---|---|---|---|---|
| New Mains | 10,707miles | 10,085 miles | 9,528 miles | 9,266 miles |
| Replacement Mains | 3,688 miles | 3,575 miles | 5,675 miles | 5,249 miles |
| TOTAL MAINS | 14,395 miles | 13,660 miles | 15,203 miles | 14,515 miles |
| New Services | 8,364 miles | 7,452 miles | 5,888 miles | 5,465 miles |
| Replacement Services | 4,385 miles | 4,542 miles | 3,975 miles | 4,309 miles |
| TOTAL SERVICES | 11,749 miles | 11,994 miles | 9,863 miles | 9,774 miles |
| Total Mileage | 26,144 miles | 25,654 miles | 25,066 miles | 24,289 miles |

**Gas Utility Expenditures, 1989-1992**

| | 1992 | 1991 | 1990 | 1989 |
|---|---|---|---|---|
| New Construction | $2,193,000,000 | $1,928,472,000 | $1,927,288,000 | $1,721,470,000 |
| 3Rs | $2,207,136,000 | $2,229,306,000 | $4,162,662,000 | $3,939,606,000 |

nomic conditions. As a result, our 1992 budget has also been reduced in this area."

"The construction budget was cut by the warmer weather and the poor economy cut back on the new business area. The 1992 budget is following along with a sluggish market."

"Budgets are based on historical data and projected trends. Repair and replacement budgets tend to be more stable than new construction expenditures."

"Warmer weather and a reduction in housing construction due to economic factors had a major effect on our 1992 budget. New construction expenditures were affected more than repair budgets."

"We can only do what has to be done if the money isn't there."

"New construction expenditures are affected because we are going through a 10-year expansion program and our system does not need that much repair."

"We had a milder winter than expected so we were able to perform more repairs."

Many companies have a schedule for replacing a certain percentage of the cast iron pipe in their system every year. Others report they base cast iron main replacements on various factors.

"Replacements are based on leak and broken-main history. Replacement is mostly by direct burial, but we are looking at live insertions."

"We replace cast iron and bare steel pipe with either plastic or coated steel based on operating pressure and size. We have a continuing program to annually replace sections of cast iron pipe, the last of which will be replaced in 1992."

"Mains are replaced with plastic and services are inserted."

"We use 'all around' repair clamps to make cast iron repairs."

"Cast iron repairs are made by shrink sleeves and encapsulation."

"Replacement program is based on size, location, age, leak history and condition of cast iron mains. Repair techniques include replacement, installation of sleeves, belljoint clamps and encapsulation."

"Cast iron repairs are primarily full-encirclement clamps and joint sealing, but internal sealants have also been used."

**Plastic pipe in 1991 again accounted for more than than 90% of the distribution piping installed by U.S. gas utilities.**

"We are attempting to do away with our low-pressure systems. When they go, so will most of our 277 miles of cast iron main."

Polyethylene pipe is the unquestioned material of choice for new and replacement services, and for mains below 8 in. As it has for several years, PE pipe accounted for more than 91% of the total miles of gas distribution piping installed in 1991, with 23,339 miles. U.S. gas companies installed 11,789 miles of PE main in 1991, 86.3% of the total main mileage during the year. PE accounted for 96.8% of the service lines installed in 1991, or 11,550 miles.

In 1992, U.S. gas distribution companies will install an expected 24,855 miles of plastic pipe, 95% of the total, including 12,552 miles of plastic mains and 12,303 miles of plastic services.

The electrofusion technique of joining plastic gas pipe has gained acceptance over the last several years. Companies reported good experience with electrofusion, particularly for repairs in the ditch and on small (1-in. or smaller) lines.

"We have had good experiences using electrofusion."

"Tapping service tees are installed exclusively by electrofusion. It is also used for repairs and tie-ins."

"We use the Lyall and Inmogaz systems for repairs and tight tie-ins on PE mains, as well as to make transitions between different types of PE. We have had good experience over the roughly 6 years we have been using electrofusion."

"We are pleased with the outcome of electrofusion methods."

"We use both butt-fusion and electrofusion in construction, and have had no problems with either process."

"Electrofusion fittings are installed daily throughout the system and we expect this process to be with us for the foreseeable future. We have not experienced any problems with conventional butt-fusion methods."

"Electrofusion is useful when segments larger than 1.5-in. in diameter must be replaced."

"Electrofusion has proven easiest to work with and reliable. We use it for repairs of mains and services and installation of new services."

"We use electrofusion basically for repairs and in construction where warranted. We have had very good success with electrofusion."

"We are currently using electrofusion on a limited basis, mainly for repair work."

"Electrofusion is excellent for repairs."

"Electrofusion works well in tie-ins and repairs."

"Voltage fluctuations with the generators has been a problem."

In addition to its easy handling, plastic pipe is attractive to many utilities for its low cost and reliable installation. Every company responding said it cost them more on a per-foot basis to install steel pipe than the equivalent diameter of plastic pipe.

"Approximate cost of steel mains is $42 ft; plastic mains, $36 ft."

"Average cost of new steel mains: $25 ft. For new plastic mains, $16 ft."

"Steel pipe installation ranges from $40 ft for a lengthy 1- in. project to $95 ft for a short 8-in. job."

"For 6-in. and smaller pipe, our costs are $9.22 ft for new steel mains installed by contractors and $8.78 ft for new plastic mains. Company-installed main costs are $12.92 ft for new steel and $6.81 ft for new plastic mains."

"Our costs range from $8.75 ft for 2-in. steel to $18 ft for 6-in. steel. **P&GJ**

# Methane Leakage In Natural Gas Operations

**by Ann Jennervik**
**Energy Planning & Environmental Issues, AF- Energikonsult Stockholm AB, Stockholm, Sweden**

(EDITOR'S NOTE: In Part 1 of this two-part article, Ms. Jennervik describes how the figures for methane emissions have been inflated by uninformed researchers and anti-gas lobbies.)

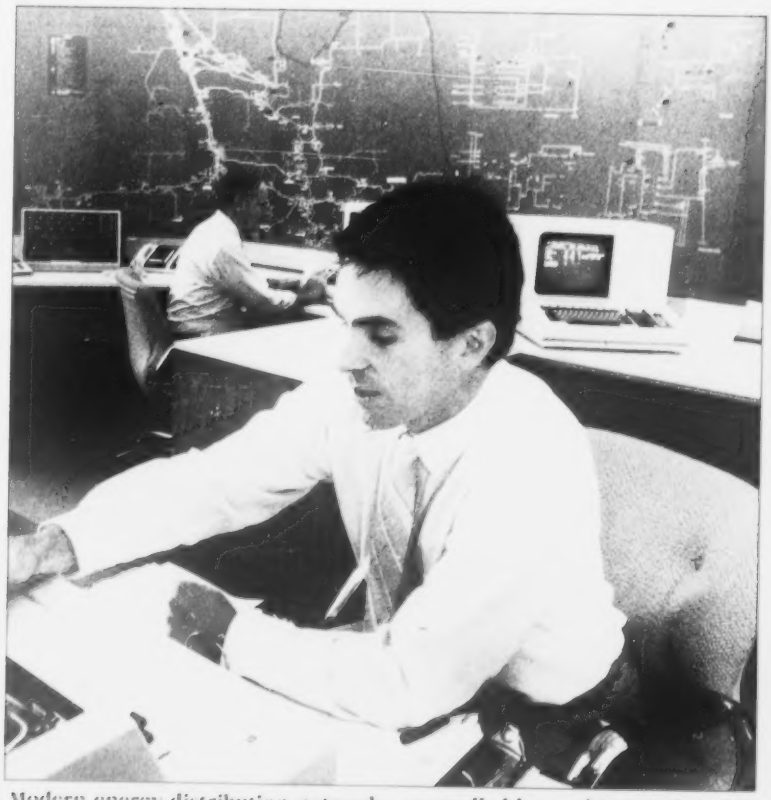
Natural gas is a small but important energy source in Sweden. Plans call for an increase from 1.5% of primary consumption currently to about 10% in 10 years and additional 5% to 10% during the first decade of the 21st century.

The environmental impact is the major concern in the Swedish energy debate today, and especially the greenhouse effect and its contribution to global warming. An intense debate concerning the use of natural gas arose in 1988 that revealed a lack of contact between gas companies and environmental scientists.

SwedeGas carried out two independent studies that summarize methane leakage from natural gas operations, from exploration to distribution. One study focused on worldwide operations with the other focusing on Sweden's existing transmission and distribution system.

These studies showed a total methane leakage of less than one-tenth the 5% to 10% of total volumes often cited by opponents of natural gas use.

- The only significant methane leakage occurs in older distribution networks originally built for manufactured or town gas that now carry natural gas.
- A weighted average of total leakage from natural gas operations worldwide is less than 1% of marketed production.
- For new supplies, the estimate of leakage is 0.05%.



**Modern energy distribution networks, controlled by sophisticated equipment and trained professionals such as those found at Consumers Power Co.'s gas control center in Michigan, keep to a minimum any release of methane that could adversely affect the global environment.**

Earlier figures quoted in the debate are misinterpreted from industry statistics. In fact, the natural gas industry itself is partly to blame for the lack of connection and exchange of information between researchers and transmission and distribution system operators.

Natural gas can and will play an important part in a clean environment by lowering the emissions of greenhouse gases.

Since 1988, the greenhouse effect and its affect on global warming has been considered a major, if still controversial, environmental problem.

Carbon dioxide is an inevitable result of fossil-fuel combustion. Natural gas has advantages over coal and oil, because its carbon content compared to its hydrogen content is the lowest of the commonly available fuels.

However, natural gas is almost entirely methane, another important greenhouse gas. Each molecule of methane has the effect of five molecules of carbon dioxide. If large amounts of natural gas were in fact seeping out from the system,

it would reduce the advantage of using natural gas instead of coal and increase the greenhouse impact of natural gas vs nuclear power.

As the influence of methane as an infra-red absorbent gas has been more widely recognized, the considerations of methane's greenhouse effect has become vitally important to gas companies around the world.

Methane leakage of 5% to 10% (multiplied by the large affect of methane on the environment) would equalize the fossil fuels. Such figures are often cited during emotional debates by advocates of coal and nuclear energy.

In 1989, the Swedish environmental authorities used the same misinterpreted figures in a proposal for a carbon dioxide- equivalent tax. Swedish energy taxes were to be revised to implement environmental premiums and change the competition among different fuels. As a result, SwedeGas AB, the country's national gas company, needed facts and figures showing the actual levels of leakage to show how absurd the cited loss figures really were. At this time, the only measurement and accurate statistics available were internal company figures.

During that summer, the Alphatania Partnership in London carried out an investigation for SwedeGas involving 41 gas companies and authorities. The aim of the study was to trace potential leakage points along the chain from exploration to the burner tip and determine their causes, potential size, frequency and measurements, so as to minimize them. A separate study was undertaken describing the Swedish gas chain, from platforms and along the pipelines to the country's 8,000 customers.

## Disinformation

When incorrect information is spread and used by scientists as well as energy professionals, it is not enough to simply provide new, more accurate information. The correction must explain the earlier information and why it should differ so widely.

The figures regarding methane leakage from gross natural gas operations varied between 4% and 10% of natural gas production. SwedeGas saw that these figures were in conflict with operational experience and had to be either wrong or falsely derived from misunderstood statistics. The figures were drawn from research documents of various sources. The sources were not always quoted or, if quoted, were themselves derived from work by other researchers. The literature seemed to feed upon itself, ignoring obvious operational data. Attempts by Ruhrgas, British Gas and the American Gas Association, among others, to correct these figures had little affect on researchers.

Among the estimates assumed in the literature of total global methane emissions to the atmosphere varied between 225 million tons and 1.2 billion tons. Within these figures, the estimate of leakage from oil and gas operations generally ranged from 20 million to 60 million tons, often calculated from a straight per-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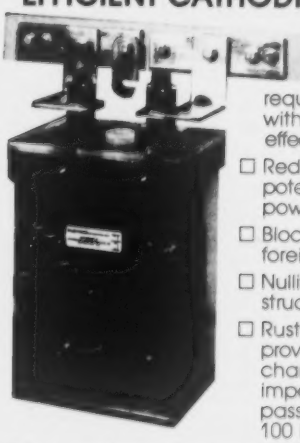

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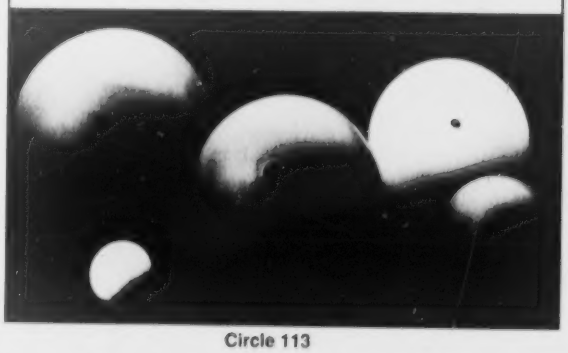

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centage of gross gas production.

There is a strong concentration of natural gas leakage figures of about 30 million to 40 million metric tons per year. The presumed percentage of the total methane emissions arising from oil and gas operations are about 5% to 10%.

However, these figures do not correspond. Thirty to 40 million metric tons are about 2% to 3% of marketed gas production, not 5% to 10%. Generally, no distinction is made between gas and oil operations as sources of methane leakage. In these estimates "natural gas leakage" does not mean leakage from natural gas operations but from oil as well as natural gas operations.

It is not always possible to identify methane leakages from published reports of natural gas production and disposition. The purpose of these statistics is to provide an overview of gas production and consumption, not detailed information about shrinkage and losses. Some methane emissions are in the "flared and vented" category, but this is mostly unmarketed associated gas derived from oil production and should not be included in the gas chain.

In these reports, losses do not simply mean leakage. "Other losses" covers shrinkage at the treatment facilities, including the stripping of natural gas liquids and other gases for commercial use. Gas used as compressor fuel and for other purposes is included in marketed production. Also, recalculations from different volume figures—standard and normal cubic meters and from cubic feet to cubic meters—can be hidden within these figures.

The international survey was carried out by collecting and investigating operational data on methane leakage from the natural gas chain. This is defined as all production, treatment, transportation and delivery of natural gas produced for sale.

The draft was submitted for comment to 41 selected companies and organizations around the world that are closely concerned with natural gas operations. They were asked to submit information and 70% have responded. As a result, the final study information was based on actual measurements, accurate statistics and net calculations from gross figures containing losses other than leakage.

## Leakages

There are two important factors that make operating companies eager to diminish methane leakage: safety and commercial reasons.

The escape of inflammable hydrocarbons presents safety hazards, particularly natural gas, which can collect in confined places. It should be noted that natural gas is inherently safer than other light hydrocarbons because of its narrow inflammability limits and speed of dispersion in the atmosphere. When unusable gas occurs, primarily in treatment facilities, it is limited to small amounts for commercial reasons and is almost invariably flared. This causes carbon dioxide but does not release methane.

Safety requirements in natural gas operations are well met by available materials, developed technology and high levels of training. Gas detectors, installed for safety at many facilities handling large volumes of natural gas, can quickly shut off the flow. Accidents where large volumes of natural gas do escape, as in the Piper Alpha platform disaster, are rare and much too small to account for even 0.01% of annual gas consumption.

Involuntary leakages are most frequent in the distribution sector, where large numbers of pipes and installations are involved. They are usually in an urban setting, where excavators can dig into them. In addition, parts of a gas utility system might use materials not suited to the efficient distribution of natural gas. However, even if a rupture occurs only relatively small amounts of gas can escape from these low-pressure installations.

Natural gas is sometimes intentionally vented for safety reasons. Maintenance, repair and replacement of gas facilities—and the connection of new customers—often require the emptying of segments of a pipeline system. The industry practice is to reduce the gas pressure as low as possible before purging the segment to be worked on. Often, the purged gas is flared during repairs.

**World Gas Chain Leakage**

| Country/Region | Marketed Production | Leakage Factor | Total Leakage |
|---|---|---|---|
| U.S | 507.22 Bcm<br>17,909.94 Bcf | 0.4% | 2.03 Bcm<br>71.64 Bcf |
| Canada | 62.99 Bcm<br>2,224.18 Bcf | 0.5% | 0.03 Bcm<br>1.11 Bcf |
| Western Europe | 259.36 Bcm<br>9,158.00 Bcf | 0.8% | 2.07 Bcm<br>73.26 Bcf |
| USSR & Eastern Europe | 784.39 Bcm<br>27,696.81 Bcf | 1.0% | 7 84 Bcm<br>276.96 Bcf |
| Rest of World | 345.8 Bcm<br>12,210.2 Bcf | 1.0% | 3 46 Bcm<br>122.10 Bcf |
| TOTAL | 1,959.47 Bcm<br>69,188.89 Bcf | 0.8% | 15.43 Bcm<br>553.51 Bcf |
| TONNAGE | 1.4 billion metric tons | | 11.02 million metric tons |

In Sweden, this type of methane leakage has occurred five times since 1985, for a total release of 415,000 cubic meters (14.6 MMcf), of about 0.04% of total gas flow. This figure will probably be lower after the construction period is completed.

Any loss or inefficient use of natural gas represents costs for the companies involved, which take steps to keep these losses to a minimum.

Gas metering in the distribution sector is not a precise activity. Gas utilities tend to have a metering accuracy that is at best +- 1.0% in practice. Meters are often not corrected for temperature and pressure. There are examples of utilities on occasion recording negative "unaccounted for" annual gas figures for this reason!

Few gas distribution systems are without at least a small amount of gas theft, generally achieved by meter tampering but sometimes by unauthorized and unmetered connections.

Such losses—which are not leakages—are often taken into account by raising the average gas price by 1% or 2%. It is better to have a slightly higher price per unit than tell a gas customer to pay for more gas than the meter shows. Therefore, meters tend to be calibrated on the low side, which shows up as losses.

## Results

Actual leakage from natural gas operations is 20% to 10% of the figures usually cited. Instead of 30 million to 40 million metric tons, the figure is actually 11.02 million metric tons.

h one exception, those commenting on the study said or inferred that precise, accurate leakage figures are hard to determine because they are generally small and difficult to differentiate from other marginal influences that make up the "unaccounted-for gas" category. However, the Canadian Gas Association said:

"Distribution systems in Canada are continuously monitored using flame-ionization techniques. From these surveys it is possible to precisely determine the number of leaks in a system and to accurately estimate the amount of gas being released due to leakage. The result is an estimate of 0.03% of all gas sold in Canada."

Even some of the respondents with direct operational data tended to over-estimate leakages from other parts of the gas chain where they are not operationally acquainted.

High losses reported in Eastern European gas systems of up to 40% could imply operating practices are not equal to quality to those of other countries. However, these losses are mostly due to inefficient use of energy and inaccurate or even non-existent metering. **P&GJ**

(NEXT MONTH: Ms. Jennervik details leakage levels for the various parts of the gas chain and in different parts of the world. These articles are based on a paper presented by Ms. Jennervik at the 18th World Gas Conference in Berlin.)


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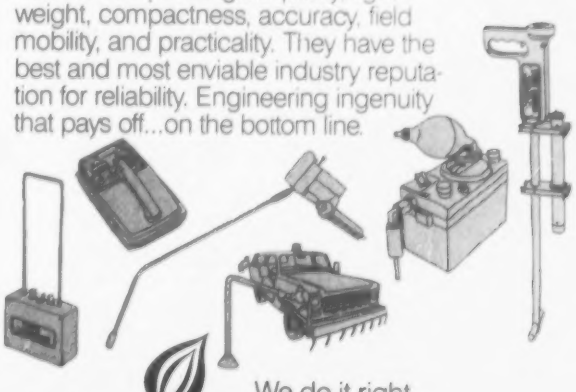

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133rd Year

January 1992

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- Contractor's Roundtable
- PGT/PG&E Expansion
- Pipeline Patterns
- Making Line Pipe
- Methane Leakage

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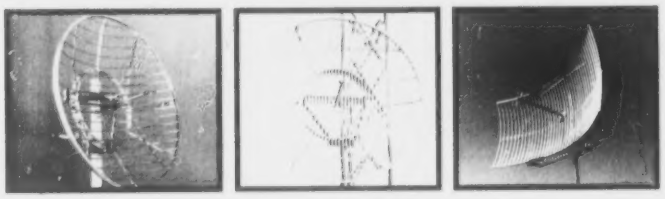

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# Pipeline & Gas Journal

**International Pipeline & Gas Utility Design, Construction & Operation**

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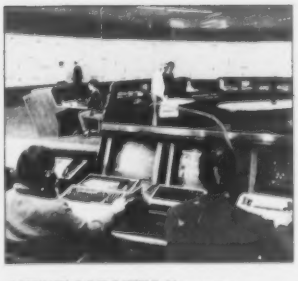
**ON THE COVER**
Pipeline contractors installed thousands of miles of new energy pipelines in North America during 1991.



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Special Report

# U.S. Natural Gas Pipeline Flow And Demand Trends

**by Margaret M. Carson**, Director of Comparative Analysis, Enron Corp., Houston, Texas

It is no surprise that regional natural gas supply and demand patterns in North America are constantly changing.

A consensus of forecasters agree that the natural gas resource base is larger than envisaged in the early 1980s due to advances in exploration and production technology. In addition, on the demand side more gas will be burned by U.S. power generators to meet growth in electricity. Gas consumption is up in the commercial sector, and natural gas is correctly seen as environmentally protective. But how much more natural gas does the U.S. need?

New pipeline projects are springing up all over the nation— 43 to be exact, with most of them connecting gas deliverability out of basins west of the Mississippi to new markets along the Atlantic and Pacific coasts. Some 3 Bcfd of new, largely interstate pipeline capacity has been brought into service since 1989. Another 3 Bcfd of incremental pipeline capacity is expected to be onstream by 1995.

Because about 3 miles of gathering pipeline are behind every 1 mile of interstate pipeline, options for moving gas from non-traditional sources are growing exponentially with pipeline construction and changes in reserve patterns due to new efficiencies in exploration and development. Of course, these changes add increasing levels of uncertainty about patterns of future U.S. gas flows.

Enron finds that the U.S. gas resource base is ample, with 1,200 Tcf according to the latest estimates. As recently as April 1989 Enron was estimating an 805-Tcf resource base. This includes 158.17 Tcf in proven reserves and 1,031.89 Tcf in total undiscovered resources. Alaskan gas is not included.

**Table 1. U.S. Supply/Base Case**

| | 1990 | 1995 | 2000 |
|---|---|---|---|
| Lower 48 Production | 16.9 Tcf<br>91% | 18.0 Tcf<br>90% | 19.0 Tcf<br>87% |
| Canadian Exports | 1.4 Tcf<br>8% | 1.8 Tcf<br>9% | 2.0 Tcf<br>9% |
| LNG/SNG | 0.2 Tcf<br>1% | 0.3 Tcf<br>1% | 0.8 Tcf<br>4% |
| **TOTAL SUPPLY** | **18.5 Tcf** | **20.1 Tcf** | **21.8 Tcf** |

**Proposed Gas Pipeline Projects**

| Number of Projects | Area | Miles | Cost,$MM | Capacity, MMcfd | CapacityAs Percent Of Total Projects |
|---|---|---|---|---|---|
| 9 | Northeast/East Coast | 1,516 | $1,800 | 2,055 | 13% |
| 7 | Gulf Coast | 440 | $290 | 2,300 | 15% |
| 15 | Midcontinent/Central | 2,020 | $1,457 | 4,393 | 30% |
| 12 | West Coast/Rockies | 4,450 | $4,398 | 6,195 | 42% |
| **43** | | **8,326** | **$7,945** | **14,943/5.5 Tcfy** | **100%** |

**Northeast/Eastern Seaboard Pipeline Projects**

| Proposed In Service | Pipeline | Miles | Cost, $MM | Capacity |
|---|---|---|---|---|
| 11/91 | Iroquois | 370 | $580 | 575 MMcfd |
| 1992 | NiaGara I &II | 592 | $586 | 500 MMcfd |
| 9/91 | Empire | 155 | $82 | 150 MMcfd |
| 11/91 | CNG/Transco I | 278 | $479 | 370 MMcfd |
| 11/92 | CNG Transco II | 278 | $479 | 370MMcfd |
| 9/91 | CNG I | 52 | $25 | 220 MMcfd |
| 1991 | Columbia/VA | 44 | $20 | 200 MMcfd |
| 7/91 | Columbia/Richmond | 25 | $28 | 40 MMcfd |
| **9 Projects** | | **1,516** | **$1,800** | **2,055 MMcfd** |

Demand growth is strong, though affected by oil price assumption sensitivities. Highlights in the areas of reserves and production include gains in both categories from fields in the Rockies/Wyoming, San Juan Basin and the Norphlet trends of offshore Alabama. The Midcontinent/Hugoton area has exhibited reserve declines in a period of flat production. In the U.S. Gulf coast offshore, both production and reserves decline over the forecast period, despite strong reserves additions.

Table 1 depicts Lower 48 production in the Enron base case, with approximate market share changes for gas exports to the U.S. and LNG/SNG. Canadian supplies are 2 Tcfy by 2000, up 600 Bcfy from the current 1.4-Tcf levels.

LNG/SNG use grows from the current 200 Bcfy to 800 Bcfy by 2000 in the base case, using the four existing U.S. LNG gasification facilities but without requiring any expansions to U.S. gasifiers. Algerian LNG (and possibly some Nigerian LNG by later in the decade) are the supply sources. Canadian exports and LNG

use could well be higher, depending on policy decisions.

Low oil prices would result in a more modest supply profile, or only 19.2 Tcf by 2000 instead of 21.8 Tcf in the base case. Demand for gas stays relatively flat in the low oil- price case, as fuel-switchable load losses are offset by growth in commercial and electrical generation use.

U.S. regional gas production trends show that traditionally, the preponderance of gas flows from the U.S. Gulf Coast offshore and Midcontinent areas to Northeast and Midwest markets.

In order to access a future 21.8-Tcf U.S. gas market and accommodate growth in deliveries from new gas basins as well as traditional areas, 43 new U.S. and Canadian pipeline projects are in various stages of progress, from awaiting completion to initial regulatory considerations.

Enron recently completed a regional survey of pipeline construction projects. The survey identified 8,526 miles of pipeline with a total capacity of 14.9 Bcfd.

The West Coast Rockies area is by far the most active in the country with proposed new pipeline capacity representing 42% of the total projects on a throughput basis. The average costs of the supply-area pipelines are lower than the market-pull projects serving the Northeast.

Although all the proposed projects are not expected to be built, and others may slip their completion dates by a year or more, at least two out of three of these projects will eventually be completed. This equates to about 4 Tcf of new annual capacity of the 5.5 Tcf as proposed.

The magnitude of these expansions are more than adequate to serve the 3.1 Tcf of market growth forecast by the year 2000 in the Enron base case.

- Two-thirds of the 2 Bcfd of Northeast and East Coast projects will move new Canadian and Midcontinent supplies to markets in the Eastern U.S. The remainder expand access to the U.S. Gulf Coast and offshore supplies for new East Coast markets.
- U.S. Gulf Coast projects total 2.3 Bcfd and largely access growing production volumes from offshore areas for East Coast markets. New projects will also move Black Warrior coal seam gas to South Atlantic markets.
- Midcontinent-Central projects provide access for 4.3 Bcfd of Oklahoma gas to Northeast and Upper Midwest market and provide outlets for Canadian gas, the new Antrim shale gas and other local production.
- West Coast Rockies projects represent up to 6.2 Bcfd from three growing sources of supply competing for markets west of the Rockies: Canadian export volumes, increamental Rockies Wyoming supplies, and rapidly increasing volumes out of the San Juan Basin. About a third of the projects provide for gas to flow both east and west.

The Enron Outlook shows a market of natural gas in the Lower 48 of 21.8 Tcfy, an 8.1-Bcfd increase from 1990.

The forecast assumes GNP growth at an annual rate of 2.6%.

Electricity consumption in the U.S. is expected to grow at an annual rate of 2.2% over the period. Gas

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used for power generation, the main growth market, grows by 1.5 Tcfy over the next 10 years in the Enron base case, from 2.8 Tcf to 4.3 Tcf. In the low oil case, the increase is only 200 Bcfy.

Gas for electric generation sustains significant gains across most regions of the U.S., particularly in the South Atlantic, Mid Atlantic and Southwestern states. Some 28,000 mw of gas-fired combined-cycle capacity will enter service by the year 2000. About half of this capacity will be independent power plants that will be able to meet both power growth needs and compliance with environmental regulations, especially after 1998, due to the Clean Air Act amendments. This is not a great deal of new electric generating capacity – representing only about 3.5% of current U.S. net generating capacity of 800 gigawatts, and about a third of the 90,000 mw of total new generating capacity needed by the year 2000.

Commercial natural gas use will increase 1 Tcf by the year 2000, led by the Pacific and Northeast markets. Compressed natural gas vehicles are included in the commercial use segment, because commercial fleets will lead the market growth due to Clean Air Act fleet mandates in 22 U.S. cities. By the year 2000, the Enron base case includes 500 Bcf of CNG use, the equivalent to about 2.5 million vehicles or

15% of commercial fleets. Commercial gas use gains are strong across the board, particularly following new pipeline capacity additions and interconnects that bring incremental gas to growth markets.

However, residential gas use in the base case is flat to the year 2000, growing just 100 Bcf. Residential gas use is relatively flat for all regions, due to conservation effects of more efficient appliances and competition from electricity that offset modest gas consumption gains. U.S. industrial gas use shows modest gains of 455 Bcf nationally, due to growth in the southwest area.

Enron finds the U.S. gas resource base is ample, according to latest estimates of 1,200 Tcf.

Demand growth is strong, increasing U.S. natural gas use to 21.8 Tcfy by the end of the century, although demand is affected by oil price assumption sensitivities. U.S. gas supplies are price responsive, and the market grows under both the oil price growth and flat oil price scenarios and various pipeline additions.

Planned increases in pipeline capacity appear on track, and are expected to stay on track barring any new tightening of pipeline construction activities by the Federal Energy Regulatory Commission. Capacity is ample to handle the increased gas demand to reach growth markets in the U.S. commercial and electric generation sectors.

Enron is confident that the U.S. gas strategy to bring gas supplies to growth markets by the year 2000 appears to be working. **P&GJ**

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# Methane Leakage In Natural Gas Operations

**by Ann Jennervik,**
**Energy Planning & Environmental Issues, AF-Energikonsult Stockholm AB, Stockholm, Sweden**

(EDITOR'S NOTE: In Part 1 of this two-part article, Ms. Jennervik described how the figures for methane emissions have been inflated by uninformed researchers and anti-gas lobbies. The initial article presented accurate and much lower figures for methane emissions. In this concluding chapter, she details leakage levels for the various parts of the gas chain and in different parts of the world.)

The world gas industry is efficient in conservation of natural gas within its systems.

As the influence of methane as an infra-red absorbent gas has been more widely recognized, the considerations of methane's greenhouse effect has become vitally important to gas companies around the world.

The industry is universally environmentally conscious. Natural gas transmission and distribution companies want to maintain their image as suppliers of clean fuel. Further reductions in methane leakage—particularly in older distribution systems—can should and will be pursued.

Unfortunately, there has been little exchange of views on methane leakages between commentators on environmental matters and gas companies and organizations. This appears to have led to a misunderstanding of figures available from the industry that has resulted in a misconstruction of the actual size of methane emissions.

There is absolutely no need for the industry to avoid the issue of greenhouse gases. Without industry involvement, the environmental debate concerning fossil fuels could lead to selective interpretation of scientific views and available evidence. Companies and authorities would be presented with confusing, contradictory evidence on which to base policy approaches and regulations.

## Exploration Leakage: 0%

Searching for hydrocarbons involves virtually no methane leakage except during very rare blow-out accidents. During a short period, gas discoveries are testing in open flow by flaring and not venting the gas.

## Production Leakage: 0.015%

Natural gas is mainly produced as non-associated gas, but about 10% is produced in association with crude oil. Apart from rare accidents, production is a leak-free operation but in some older installations gas is vented rather than flared. In most oil production the gas is flared or reinjected into the formation.

## Treatment Leakage: 0.001% to 0.002%

Most gas is treated after production to remove valuable or undesirable components, such as LPG, car-

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bon dioxide and sulfur. Hydrocarbon releases are flared.

## Transportation Leakage: 0.001% to 0.13%

Modern materials used in gas pipelines are virtually leak-free. Potential leakage points include flanges and packings, where gas could leak out if the amounts are small enough to avoid detection. Internal figures from system operators all indicate gross leakage figures below 0.01%.

Maintenance, especially repairs, are the main potential leakage points. These could total some hundreds of a percentage point. Normal maintenance, including valve replacements and pigging operations, result in leakage of less than 0.0002%.

Accidents where pipes or other installations are damaged could, calculated by using a statistical frequency of accidents, add another 0.002%.

Transportation of natural gas on LNG carriers is only 3% of world marketed production. LNG boils off at -160°C, and most vessels contain features to curtail, use or re-direct the methane. Most use it as an engine fuel, along with bunker oil. In rare occasions, rough weather causes excessive boil off. Some of this is vented by ships not equipped with flares. This leakage is less than 0.05% of the volumes carried annually.

Natural gas storage is also part of the transportation system. These facilities are in effect an operating gas field with a controlled gas flow, with virtually zero leakage.

Distribution Leakage: Modern systems: 0.05% to 0.4%. Older systems: Maximum of 1%.

Older distribution networks are the only parts of the natural gas chain with significant leakage. These systems, mainly in England and Germany, add many customers each year so old pipe is continually replaced by modern, leak-free pipe.

It is difficult to separate true leakage from metering differences. Elderly town-gas systems, made primarily of cast iron pipe, are reported to have losses of 5% to 10% of gas moved through the system.

## Country-By-Country

Austria: Official figures of unaccounted-for gas fluctuate between 0.7% and 0.8%, but these include gas consumed for "own use" and flared gas. (Source: Austria Ferngas)

Denmark: In 1988 the loss of gas in the transmission system was 0.01%. (Source: Dansk Naturgas)

France: No leakage or loss from production; loss from distribution are less than 0.5%. (Source: Gaz de France)

Japan: Unaccounted-for gas accounts for less than 1% which is the difference between gas sendout and sales volume. This includes instrument error, time lag, temperature variations and other factors. Leakage is therefore a much lower figure. (Source: Osaka Gas Co.)

Netherlands: No leakage or discharge of methane in the produc-

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tion phase. Downstream losses are less than 0.4%, virtually all of it from older distribution networks. (Source: Gasunie)

UK: Leakage in the gas chain is just over 1%, maximum. In the total British Gas system, the only significant emissions arise from low-pressure systems and account for less than 1% of throughput. There is a program going on to further reduce low-pressure leakage. As new customers come onstream, older parts of the distribution network are replaced. (Sources: British Gas and UK Department of Energy)

U.S.: Total unaccounted-for and vented-or-flared gas has average below 2.5% of total production over the last decade, but only 0.5% to 1.0% is believed to be actually vented into the atmosphere. Gas losses attributable to leakage or damaged facilities appears to be in the range of 0.2% to 0.5% of production, but there is considerable uncertainty. Venting may represent approximately 0.2% in production, but this is mainly in regard to associated gas. Downstream emissions are in the order of 0.2% to 0.3%. Transmission pipeline leakage accounts for 0.13% of throughput. (Sources: American Gas Association and the Interstate Natural Gas Association of America)

Western Germany: Losses, upstream as well as downstream, are less than 1%. Virtually all are in distribution. A parliamentary committee's assumption that methane totalling 5% of gas consumption escapes is certainly mistaken. Studies by Ruhrgas AG have shown that methane losses between the point of production and the point of use total less than 1% of gas burned by users in the western sector. (Source: Ruhrgas)

## Conclusion

Natural gas can play an important role in reducing greenhouse gas emissions.

Replacing fuels with high-carbon content is one approach, but an even more important choice is to use energy more efficiently.

Natural gas has several outstanding attributes in this respect:

- Practically no energy is used or wasted in gas transportation.
- Gas has a higher efficiency in electricity production and significant possibilities exist in combined heat and power applications.
- Direct use of gas in industrial processes could achieve energy savings of 20% to 70%.
- Replacing electricity with gas for heating and cooking purposes would reduce the amount of greenhouse gas emissions to a sixth of the emissions from coal-fired generating plants. **P&GJ**

ABOUT THE AUTHOR

Anne Jennervik, MSc, has been involved in the natural gas business in Sweden for 11 years. Before joining AF- Energikonsult, she was responsible for environmental issues in connection with natural gas at SwedeGas AB, the national gas company.

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